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ABSTRACT

This paper reports the results of a study in which interviews were conducted with each of 35 sixth graders who made errors that might have been due to reading on the word problem portion of the Metropolitan Achievement Test. To discover evidence of poor reading affecting word problem success, the investigators asked each child to read aloud those problems answered incorrectly in which reading might have contributed to the error that was made. Children were asked to explain the situation in the problem, to identify the question being asked, and to tell how the problem should be worked. Findings showed that although many children did not know how to do the work, they could read and interpret the problems. Finally, audio reading times were measured to discover evidence that slow reading caused failure; little such evidence was found. (DT)

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An Abstract of

A SEARCH FOR READING DIFFICULTIES AMONG ERRED WORD PROBLEMS

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To discover evidence of poor reading affecting word problem success, children were asked to read aloud their erred problems from a standardized test. Further, they were asked to explain (a) the situation, (b) the question being asked, and (c) how the problem should be worked. Although many did not know how to do the work, they could read and interpret the problems. Finally, audio reading times were measured to discover evidence that slow reading caused failure; little such evidence was found.

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A SEARCH FOR READING DIFFICULTIES AMONG ERRED WORD PROBLEMS

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One of the most persistent assumptions about children's difficulties with word problems is that reading plays a decisive role. This assumption is so embedded in professional thinking that it remains in spite of rather severe challenges and weak support (Knifong & Holtan, 1975). It is acknowledged that if a child cannot read a problem then he certainly cannot work it. It is further acknowledged that: a. It is possible to construct a word problem which can be solved by simple arithmetic operations and yet which is written in such a style that grade school children cannot decipher its meaning. And b. A typical classroom will contain a few students, usually one or two, who are dramatically behind grade level reading ability and probably other subjects as well. The issue is not whether reading underlies success in word problems--that is assumed. Rather, the issue is whether poor reading skills typically contribute to failure, or whether that failure is due to some other factor(s).

The written work of 35 sixth grade children on the word problem portion of the Metropolitan Achievement Test (1958) was analyzed in a previous study (Knifong & Holtan, 1975) and the individual erred problems were placed into two disjoint categories. Category I contained all erred problems which could be identified from the written work as resulting from a clerical (3%) or computational (49%) error. Category II contained all other erred problems (48%)--those which offered ambiguous or non-existent written

evidence as to why they were missed. If there was any doubt about a problem or if there were apparently two sources of error, preference was given to Category II; thus, the reported number of mistakes which might have been due to reading was slightly inflated.

Computational and/or clerical error was identified as the sole source of difficulty for 52% of the erred problems. Hence, if reading factors contributed to the total set of erred problems, they could have only influenced problems in Category II. To seek out such influence, each of the 35 students from the first study was interviewed 4-6 weeks after the written test concerning Category II problems, i.e., problems in which reading might have contributed to the error. (For a discussion of the sample see Knifong & Holtan, 1975.)

The Interview

In the first study two independent raters categorized the erred problems. Of the 240 problems assigned to Category II by either rater, 218 (91%) were examined in this study. The remaining 22 were lost due to a faulty recording device, mumbling and interviewer oversight.

The interviews were conducted in the school, during the school day and were recorded on tape. All (except two) were completed in one sitting. Since some children read as many as 20 or as few as 2 or 3 problems, the interviews ranged from 10 to 65 minutes in length. The reported statistics were compiled from audio recordings which established permanent data and served as a control for interviewer bias. Misleading remarks or questions by the interviewer were recorded and taken into account as the raters interpreted the child's response.

Since only one child missed the first problem in such a way that there was any doubt about his reading ability, it was used as an initial practice problem for the interview. After this beginning, each child's Category II problems were considered in the order which they appeared on the test. For each the interviewer would ask the child:

a. "Please read this problem aloud."

After this first reading the interviewer would cover the problem and ask the following questions, pausing after each to allow a full, unhurried answer:

b. "What kind of situation does the problem describe?"

c. "What does the problem ask you to find?"

d. "Do you know how to work this problem?"

Although it was not part of the planned study, the interviewer would sometimes ask:

e. "Would you look at the problem again and point out any words which gave you difficulty?"

Since a person normally re-reads a word problem he is working, the interviewer would allow the child to re-examine the problem at any point in the questioning. The problem was initially covered to encourage the child to use his own words in answer to b and c, instead of quoting the text.

Although a few children mentioned they recognized the test, the interviewer gave no indication of problems missed and previous work was not present or mentioned any any way. Nor was the purpose of the interview explained other than, "I need you to read and discuss certain problems so that I can tell how children think."

Since audio recordings controled the influence of inadvertent, biasing remarks, it was not necessary for the interviewer to precisely follow the script for each item. He was free to discuss or reword questions as needed. For a puzzled child, question c sometimes became: "If you knew the answer to the problem, what would that tell you?" And question e: "Are there any 'hard' words in that problem?" Such freedom is invaluable for relieving anxieties and coaxing reluctant children to participate in an interview with an adult stranger.

Rater Criteria

Each child's response to the above items was judged by two independent raters as a correct response, uncertain response or incorrect response. The uncertain rating was used for ambiguous responses and those few times when there was no response. Since item 3 asked for a "yes" or "no" response only, a single rating was completed for that item.

A. "Please read this problem aloud."

For the auditory reading to be judged correct the problem was read (1) precisely by the child, (2) with spontaneous corrections by the child, or (3) with phrase or word substitutions which would not interfere with a third party's interpretation and working of the problem. On the other hand, incorrect responses contained number or word substitutions which would prevent a third party from interpreting and working the problem (e.g., reading "five when a "9" appeared on the printed page).

Errors were rare; occasional word substitutions, mispronunciations and pauses (when the student encountered an unfamiliar word) were the only auditory errors found. Such occasional lapses are common in normal speech and do not necessarily reflect misunderstanding.

B. "What kind of situation does the problem describe?" and C. "What does the problem ask you to find?"

To be judged correct, a response to item b or c had to describe the context of the situation or the question being asked (respectively). Unlike auditory reading, substitution of a wrong number in the description of the situation (a relatively rare occurrence) was not considered incorrect. These two items assessed the interpretation of the written problem and that interpretation would be the same for nearly all number substitutions. In addition, such errors are clerical in nature and normally would be corrected during the working of the problem, an activity which was not part of the interview.

When children responded and then spontaneously altered their response, the last response was used in the ratings. Incorrect responses occurred when the child explained a situation or question not present in the problem. For example, one child described the context of two girls bringing sea shells for a science corner as, "One girl brought sea shells and the other took some away."

D. "Do you know how to work this problem?"

A correct response occurred when the child indicated the operations and numbers to be used to solve the problem. The child did not have to name the numbers but only had to indicate which ones would be used, e.g., in the sea shell problem, some children said, "Add the two numbers together." Or, "Add all of the shells." In multi-step problems directions occasionally became more complicated: "And then you take that number and subtract the total amount paid." Incorrect responses were frequent and consisted of two main types: The child would shrug, smile and say, "I don't know." Or the child would indicate an incorrect operation or incorrect series of operations.

Results

Response frequencies

Insert Table 1 about here.

Even assuming a bias interpretation, it was difficult to imagine reading accounting for more than 10% of these erred problems. The relatively large number of problems which children could not work were not evidence that they could not read and interpret those problems--issues which were dealt with by the first three questions. In fact, the frequencies for the first three items were skewed so strongly against reading that the low reliability coefficient for the second item could not be seen as the fault of the raters or their criteria.

Of those 126 times the interviewer asked the children if there were troublesome words, only 10 responses were affirmative. At least 7 of these cases were associated with a typographical anomally which seldom occurs in printed texts. The word "linoleum" was hyphenated at the end of a line.

Audio reading times

To further describe reading's elusive role it was hypothesized that although these children read and interpreted the problems, perhaps some read so slowly as to cause failure. Accordingly, the verbal reading times for the first and last problems of the test were measured to the nearest half-second; and the total number of blank responses was counted for each child, as well as the number of blank responses at the end of the child's effort on the written test.

Insert Table 2 about here.

The correlations between reading times of the first problem and the last problem with the (a) number of problems left blank at the end of the test, (b) total number of problems left blank, or (c) total number of problems missed were weak.

Insert Table 3 about here.

To clarify the possible interaction (R = .53 and .57) between these factors the students were grouped high and low (using the median of the measurements) and X^2 was computed for: (a) high and low reading times of the last problem x high and low numbers left blank at the end of the test; and (b) high and low reading times of the last problem x high and low total number of problems left blank. The statistic was not significant at the .05 level in either case.

Insert Table 4 about here.

Finally, the students were rank ordered by reading time for the last problem, and the child who took the longest time to read the last problem also left the most total blank responses and the most blank responses at the end of the test. The child who took the second longest time reading the last problem ranked third as leaving the most problems blank at the end of the test. After these two cases, further trends were not apparent.

Insert Table 5 about here.

The two correlations (.53 and .57) and the two extreme cases appearing in the rank ordering of students provided some evidence of slow reading being associated with failure. However, there are three reservations. First, the fact that neither of the two correlations produced a significant X^2 suggests that the principal interaction occurred at the extremes of the sample. This interpretation was substantiated by the rank ordering and was assumed as a basic tenet at the beginning of the study. Second, the two students mentioned may have been having difficulty in both reading and arithmetic for some third, undisclosed reason(s). In fact, Balow (1964) accounted for the interaction between reading and word problems by their mutual interaction with IQ.

Third, the slowest reading rate (28.5 seconds for the last problem) was 82 words per minute and the average was 154. A person reading the 847 word test at these rates could finish in 10.3 and 5.5 minutes respectively. It is unlikely that allowing slower readers an extra 5 or 10 minutes on this extended 55 minute test would have improved their test scores appreciably. (Within the restraints of the first study, it was not possible to determine whether slow reading would be a factor in timed tests; nor was it felt that this question was of principal interest to teachers.)

Conclusion

The investigators sought evidence of poor reading abilities effecting children's success on word problems; but they found little such evidence. All problems worked correctly and, on the basis of written work, all erred problems whose responses showed that the child had read the problem well

enough to work it were excluded. Children were then interviewed on those erred problems in which reading skills might have been a factor.

The first issue was whether children could read the problems aloud. Accordingly, each child was asked to read aloud those problems which were suspect; they maintained a high rate of success on this task. The natural challenge to such success was to ask whether they understood what had been read. Hence, the children were asked to explain the setting and what the problem was asking them to find. Again they were successful in these tasks. Finally, the children were asked how the problem should be worked and here the pattern of success was broken. Many (after responding correctly to the first three items) indicated that they could not work the problem. But this failure could not be claimed as evidence of reading difficulty.

One might suggest that reading's effect is of a different nature than assumed above, e.g., perhaps word problems are missed because some children read slowly. Correlations were computed between the reading times of the first and last problems of the test and the (a) total problems left blank, (b) number of problems left blank at the end of the test, and (c) total number of problems missed. The two strongest correlations occurred between the reading time of the last question and (a) and (b) above (.53 and .57 respectively). However, X^2 between high and low groupings of these factors showed no significant difference. Last, students were rank ordered by their reading times for the last problem, and the two slowest readers of the last problem also left many problems blank. Hence reading habits of two of the 35 students may have contributed to error. This meager evidence for reading was in spite of 470 missed problems (45% of the 1050 student/problems--35 students x 30 problems).

Documenting an existing phenomenon is always easier than documenting the nonexistence of a unicorn. This study contains several loopholes which prevent the assertion that reading does not contribute to children's failure. (1) Reading may contribute to difficulties with word problems in a manner not yet imagined. (2) Reading may contribute to difficulties in fourth grade arithmetic or possibly ninth grade algebra, but not in the sixth grade. (3) This particular group of students may have been exceptional in some way which allowed them many errors for reasons other than reading. Or (4) This set of standardized test questions may have been atypical in such a manner that children read them easily and still erred.

Such questions always exist concerning any study, but they become crucial if the nonexistence of a factor is considered. The strongest claim which could be made from this data was that if reading affects word problem success, it was not revealed by these methods. However, this finding along with rather limited research supporting reading as a factor (Martin, 1963 and refutation Balow, 1964; Lyda & Duncan, 1967 and refutation, Kane, 1967; Knifong & Holtan, 1975, for a brief review) forms a basis for challenging those who believe reading plays a decisive role.

Until this challenge is accepted and evidence is shown of word problem performance among ordinary students being hendered by reading the best recommendation which can be made to teachers is: (1) Help students develop computational skills. And (2) Do not expect work on reading skills (which may be valuable in its own right) to correct word problem difficulties --except for those who are dramatically behind grade level.

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Table 1

The Mean Frequency of Responses to the Four Major Interview Items

Mean Frequency of Responses to the Directive/Question:	Correct Response	Uncertain Response	Incorrect Response	Total No. of Disagreements[a]
"Please read the following problem aloud."	208 95%	1.5 1%	8.5 4%	6
"What situation is the problem describing?"	214 98%	2 1%	2 1%	8
"What is the problem asking you to find?"	201.5 92%	6.5 3%	10 5%	20
"How would you work this problem?"	78 36%	37 17%	103 47%	43

Note: The criteria used by the rater to judge these responses are described in the text.

[a]The reliability, corrected by the Spearman-Brown formula, is: for the entire table, .85; for the first item, .82; for the second, -.03; for the third, .57; and for the last, .81. The small coefficients for the second and third items is attributed to the small numbers in the Uncertain and Incorrect Response categories. E.g., the second rater only classified one problem out of the 218 as being uncertain and none as being incorrect.

Table 2

Reading Times for the First and Last Test Items

Problem 1.

Ruth brought 15 sea shells for our science corner and Betty brought 7. How many shells did the two girls bring?

N = 35

Total number of words	21
Total number of sentences	2
Mean reading time	7.6 seconds
Range	6.0--11 seconds
Average reading rate	168 words per minute
Range	210--114.5 words per minute

Problem 30.

Carol is paid 80¢ an hour for babysitting. On Friday she worked from 8:30 to 10:30 in the evening and on Saturday from 7 to 9:45 in the evening. How much money did she make during the week end?

N = 25*

Total number of words	39
Total number of sentences	3
Mean reading time	15.2 seconds
Range	10.5-28.5 seconds
Average reading rate	154 words per minute
Range	223--82 words per minute

Note: The total number of words on the test was 847.

*Ten of the 35 students did not read this last problem since their written response showed they had read and understood the problem.

Table 3

Correlation Coefficients for Interview Reading Times X
Test Problems Left Blank or Missed

	Total No. Missed	Total No. Left Blank	No. Left Blank At End of Test
Reading Time of First Question	.31	.48	.40
$N_1 = 35$			
Reading time of Last Question	.46	.53	.57
$N_2 = 25$			

Table 4

X^2 for High and Low Interview Reading Times X Problems Left Blank on Test

Total Number of Problems Left Blank

		Below Median	Median or Above
Reading time of last problem	Below Median	7	5
	Median or Above	5	8

X^2 = .99 Median of Reading Time = 14

N = 25 Median of Total Blanks = 4

Number of Problems Left Blank at End of Test

		Below Median	Median or Above
Reading time of last problem	Below Median	7	5
	Median or Above	6	7

X^2 = .37 Median of Reading Time = 14

N = 25 Median of End Blanks = 2

Note: .05 level of significance for X^2 is 3.841

Table 5

A Rank Ordering of the Eight Longest Reading Times for the Last Problem

Time in Seconds	Total Missed	Total Left Blank	No. Left At End	Time to Read First Problem (seconds)
28.5	24	17*	15*	10
21.5	16	10	10	8.5
18.5	18	2	0	6.5
18	13	4	3	8
18	15	0	0	7.5
17	22	12	5	8.5
17	25*	16	5	11*
16.5	11	3	1	10.5

*Indicates the greatest number for this factor among all 35 students.